EFFECT OF NITROGEN FERTILITY ON AGRONOMIC PARAMETERS AND ARTHROPOD ACTIVITY IN DRIP IRRIGATED COTTON

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Abstract

The relationship between nitrogen fertilizer application in cotton and subsequent changes in lint and seed yield is well-understood. However, little research has been done to evaluate the role of nitrogen fertility in arthropod population abundance in cotton, particularly in a high yield potential subsurface drip irrigation production system. Previous work suggests that there exists a non-linear relationship between soil nitrogen availability and cotton aphid abundance in cotton. However, interaction between plant-available soil nitrogen and moisture ultimately determines arthropod population dynamics, at least for the cotton aphid. Also, there is a lack of information on plant parameter values with respect to varying rates of available soil nitrogen in cotton production. A multi-year comprehensive field study has been planned to examine the effect of soil nitrogen (residual nitrogen plus applied nitrogen) on cotton agronomic growth parameters and arthropod abundances under a drip irrigation production system. Fixed-rate nitrogen application experimental plots, previously established and fixed for five years prior to the initiation of this study in 2008, consisted of five augmented nitrogen fertility levels (0, 50, 100, 150, and 200 lb/acre) with five replications. Each year, soil in each experimental plot was sampled for residual nitrogen analysis immediately prior to planting. Rates of applied N exceeding 100 lb/acre resulted in higher residual nitrogen detection during the following season. However, variation in residual nitrogen did not significantly affect early plant growth (plant height, root length, or leaf area). Increased N levels corresponded to increased leaf chlorophyll content, but leaf chlorophyll content was generally consistent across nitrogen levels exceeding 100 lb/acre. Aphid abundance was significantly lower in zero N plots versus other plots. Rates of N application exceeding 100 lb/acre resulted in higher lint yield, but micronaire values were generally significantly reduced.

Introduction

A three-year study was conducted near Lamesa, Texas, under a limited irrigation production system (Bronson et al. 2006) to characterize the effect of nitrogen application on leaf moisture and leaf nitrogen content in cotton and the resulting influence on cotton aphid population dynamics (Matis et al. 2008). Leaf nitrogen content did not vary with nitrogen application method (variable N versus blanket N application of an optimal amount), but both the blanket application and variable-rate application resulted in significantly higher leaf nitrogen contents than were noted in zero-augmented nitrogen plots. As nitrogen application rates were increased from zero to an optimum rate, a significant decrease in both aphid birth and death rates occurred, translating to a decrease in crowding and an increase in aphid survival (Matis et al. 2008). While these data certainly help to characterize cotton aphid population dynamics between zero nitrogen fertility management and optimal nitrogen application rates, the population dynamics of cotton aphids and other cotton arthropods have not been examined under a full range of nitrogen fertility rates (Parajulee 2007; Parajulee et al. 2006, 2008). In particular, no known study has produced plant growth parameters or fruiting profile data pertaining to a spectrum of nitrogen application rates in cotton. The objective of this study was to evaluate, in cotton growing under a subsurface drip irrigation production system, cotton crop growth parameters and arthropod population abundance, as influenced by varying N fertilizer application rates.

Materials and Methods

The study was conducted at the Texas AgriLife Research farm near Plainview, Texas. A 5-acre sub-surface drip irrigation system had been in place for six years prior to this study. Plot-specific nitrogen fertility treatments had been applied in a randomized block design with five replications since 2002. Five nitrogen application rates (0, 50, 100, 150, 200 lb/acre) had been deployed to the same experimental units consistently for five consecutive years to induce maximum discrimination among treatment plots through variation in soil residual nitrogen.

The study reported herein was conducted for two years (2008 and 2009). Soil residual nitrogen was monitored annually by taking two 24-inch core samples from each plot. The 0-12 inch portions of each core were combined to form a single, composite soil sample, and likewise, the 12-24 inch portions were combined, resulting in two samples per experimental plot. Samples were sent to Ward Laboratories, Kearny, Nebraska for analysis. A high-yielding FiberMax cultivar, FM 960 B2R, was planted on May 13 (2008) and May 20 (2009). The experiment consisted of a randomized block design with five treatments and five replications. The five treatments included side-dress applications of nitrogen fertilizer at rates of 0, 50, 100, 150, and 200 lb N/acre. Cotton was planted (target rate of 56,000 seeds/acre) in 30-inch rows and was irrigated with a subsurface drip irrigation system.

Leaf area, plant height, and root length were measured on July 3 (2008) and July 20 (2009) to evaluate the influence of residual nitrogen on early plant growth patterns. In 2009, leaf chlorophyll content was also measured from 5th mainstem node leaves (n=10 leaves per plot) weekly from July 30 to October 1 (10 weeks). Soil samples were taken from the experimental plots on July 14 (2008) and July 6 (2009) for residual nitrogen analysis. Crop growth and insect activity were monitored throughout the season. Fertility treatments were applied on July 18 (2008) and July 10 (2009) with a soil applicator ground rig. COTMAN SQUAREMAN monitoring was used to monitor early plant growth, and was followed by measurement of Nodes Above White Flower (NAWF). Pre-harvest plant mapping was used as an indicator of fruit load. Foliage-dwelling mobile arthropods were monitored weekly using a Keep It Simple Sampler (KISS; Beerwinkle et al. 1997) to collect insects from upper-canopy foliage, beginning from square initiation and ending at crop cutout.

Cotton aphid populations did not develop in 2008, despite repeated applications of cyhalothrin intended to stimulate aphid population growth. Thus, neither aphid counts nor leaf nitrogen were monitored in 2008. In 2009, aphid abundance was monitored from August 20 to September 17 (5 weeks) while leaf nitrogen was monitored from July 30 to October 1 (10 weeks). Hand-harvested yield samples were obtained from each plot. Fiber samples were analyzed for lint quality parameters at the Cotton Incorporated Fiber Testing Laboratory (North Carolina).

Results and Discussion

In both study years, soil residual N levels were significantly higher in plots which received the two highest application rates of N fertilizer versus plots which received lower-rate N applications, excepting plots which received zero N in 2008 (Fig. 1). In addition, soil in plots having received the two highest rates of N application treatment exhibited similar residual N amounts. Even though some variation in plant height, root length, and leaf area was noted early in the crop season, differential amounts of soil residual N generally did not influence early plant growth (Figs. 2-4). Measured leaf chlorophyll content varied with nitrogen application level, and measured leaf chlorophyll contents from cotton in those plots which received 0 lb N/acre or 50 lb N/acre were ascertained to be significantly lower than all others (Fig. 5). Cotton in plots which received the three highest nitrogen application rates (100, 150, and 200 lb N/acre) exhibited relatively consistent measured leaf chlorophyll readings (Fig. 5). It is noteworthy that the leaf chlorophyll content in zero N treatment plots declined precipitously beginning in late August, when plants began allocating much of their resources to boll maturation, whereas this phenomenon did not occur in plots that received ≥50 lb N/acre. Cotton aphid abundance was very low in 2008 and aphid monitoring was abandoned in that year. Cotton aphid activity began in late August in 2009, and densities peaked in early- to mid-September. Cotton aphid densities were significantly lower in 0 lb N/acre treatment plots compared with that in N augmented plots located only feet apart (Fig. 5). There were no significant differences in aphid densities across N augmented plots.

Nitrogen fertility level influenced boll maturity. Bolls in zero applied N plots tended to mature significantly earlier than in N augmented plots. Laboratory measurement of boll exocarp penetrability showed that bolls from zero N augmented plots required significantly greater pressure to puncture the exocarp versus that required to do so for bolls from N augmented plots (Fig. 6). Cotton in zero N plots were terminated with harvest aid application much earlier than did cotton in N augmented plots, although data depicting this are not shown here. Variation in soil residual N levels, coupled with variable N application, resulted in phenotypic expression of nitrogen deficiency in cotton across treatment plots, especially between zero N plots and N augmented plots. The zero N plots produced the lowest yield (1,236 and 1,049 lb/acre in 2008 and 2009, respectively) (Fig. 7). Yield increased curvilinearly with each additional 50 lb N added, with the numerically highest average yield (1,742 and 1,591 lb/acre in 2008 and 2009, respectively) occurring in augmented 150 lb N/acre treatment (Fig. 7). In both years, yield increased curvilinearly with added N, but the yield did not significantly increase beyond 100 lb N/acre with additional N.

Consistent numerical decline in yield beyond 150 lb N/acre between the two years suggests that N application beyond 150 lb/acre may be unfavorable for cotton yield. Also, lint quality parameters, particularly micronaire values, were significantly lower in 150 and 200 lb/acre plots compared with those observed in lower N plots (Fig. 8). Reduced micronaire values resulted in a lint value discount in loan values.

Acknowledgments

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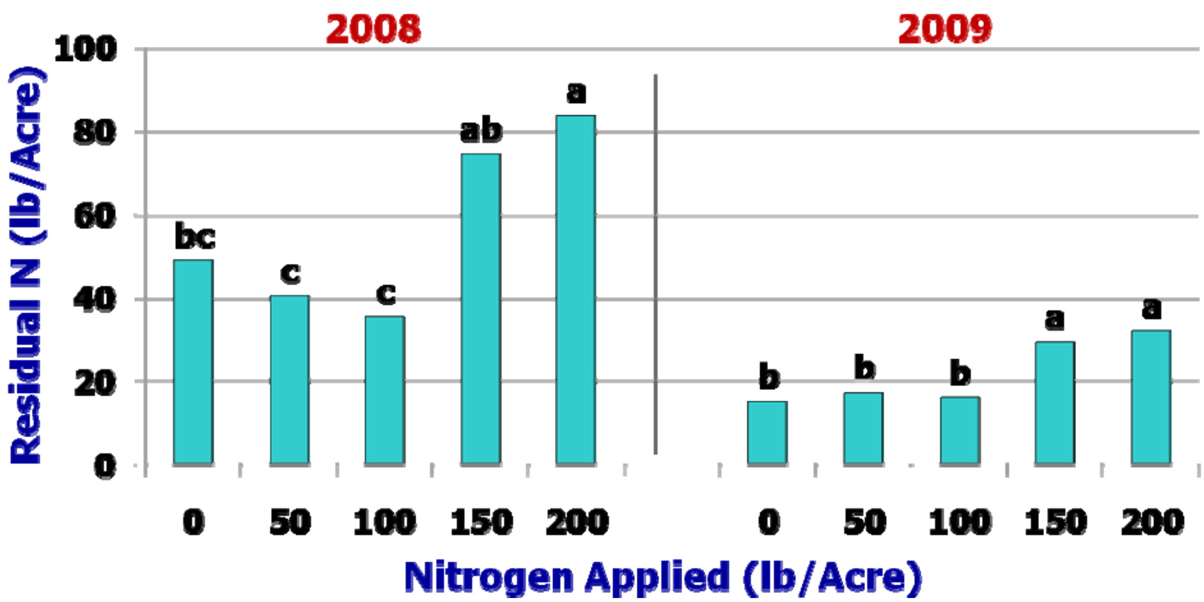

Figure 1. Effect of nitrogen application rates on residual nitrogen after six years of repetitive applications, 2008-2009.

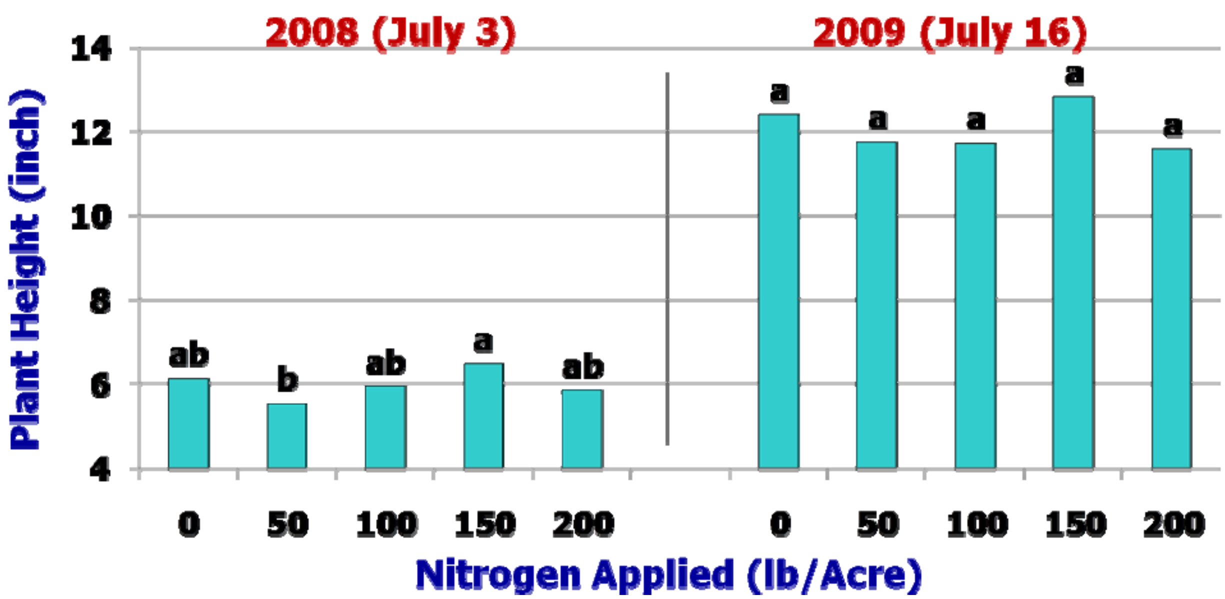

Figure 2. Effect of residual soil nitrogen on early plant growth as measured by plant height, 2008-2009.

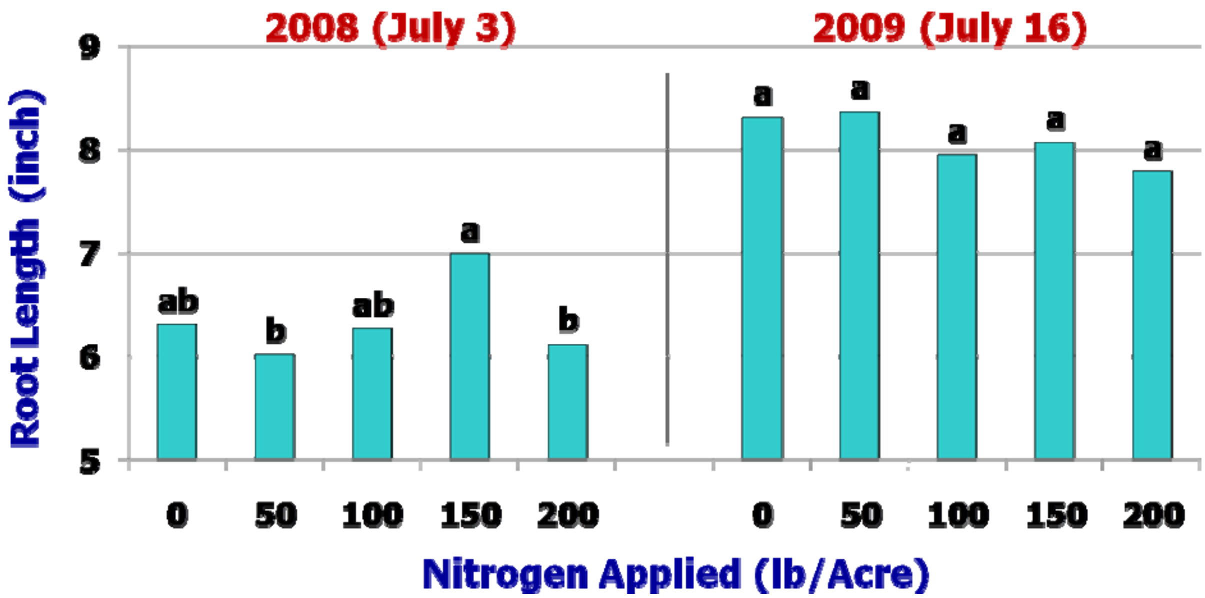

Figure 3. Effect of residual soil nitrogen on early plant growth as measured by root length, 2008-2009.

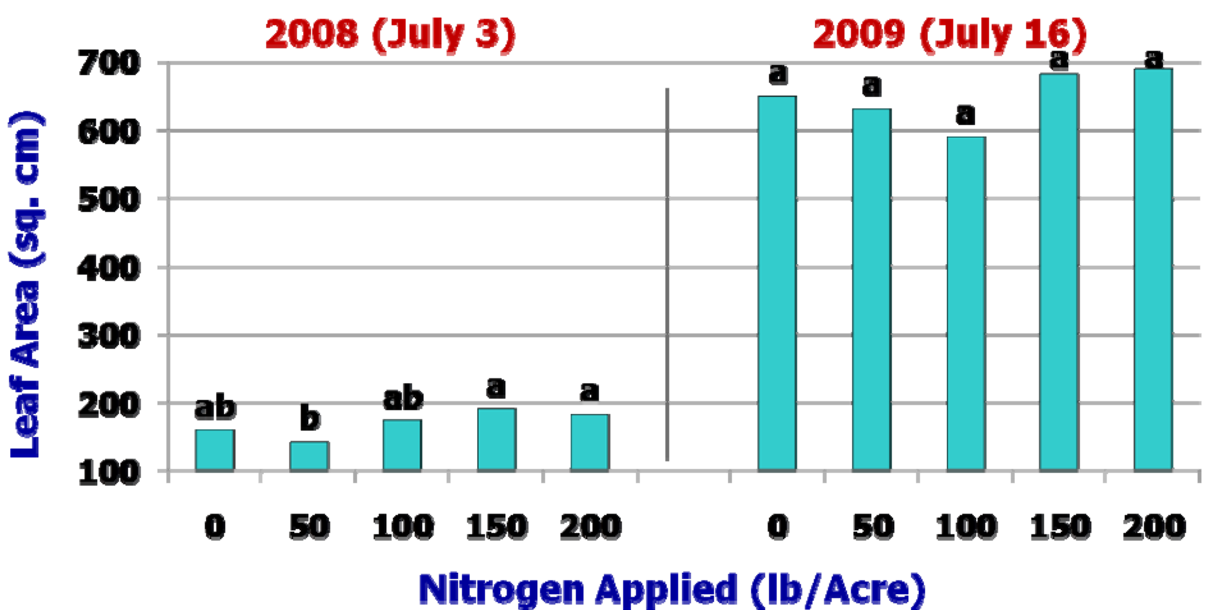

Figure 4. Effect of residual soil nitrogen on early plant growth as measured by total leaf area, 2008-2009.

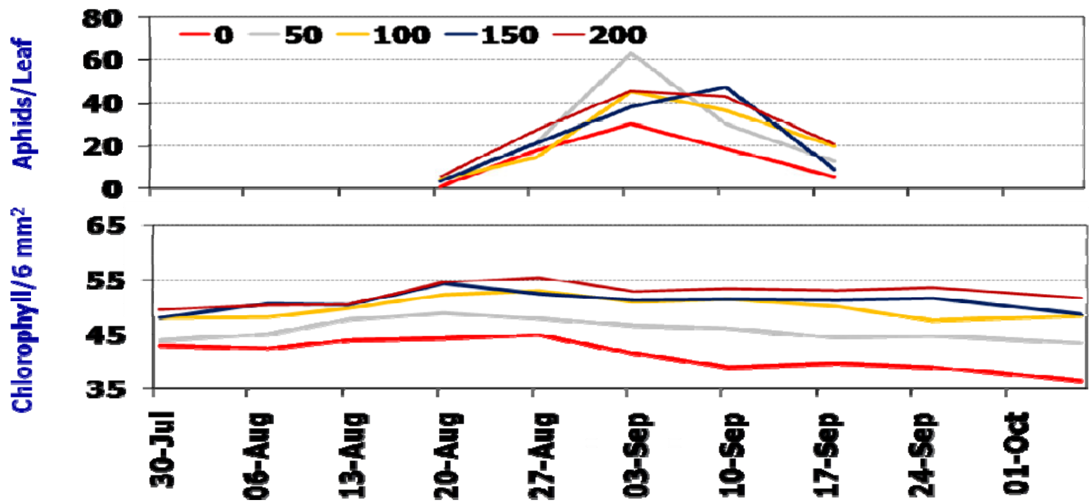

Figure 5. Temporal dynamics of cotton aphid abundance and cotton leaf (5th main stem leaves) chlorophyll content as affected by variable rates of nitrogen application into the soil of replicated experimental plots, 2009.

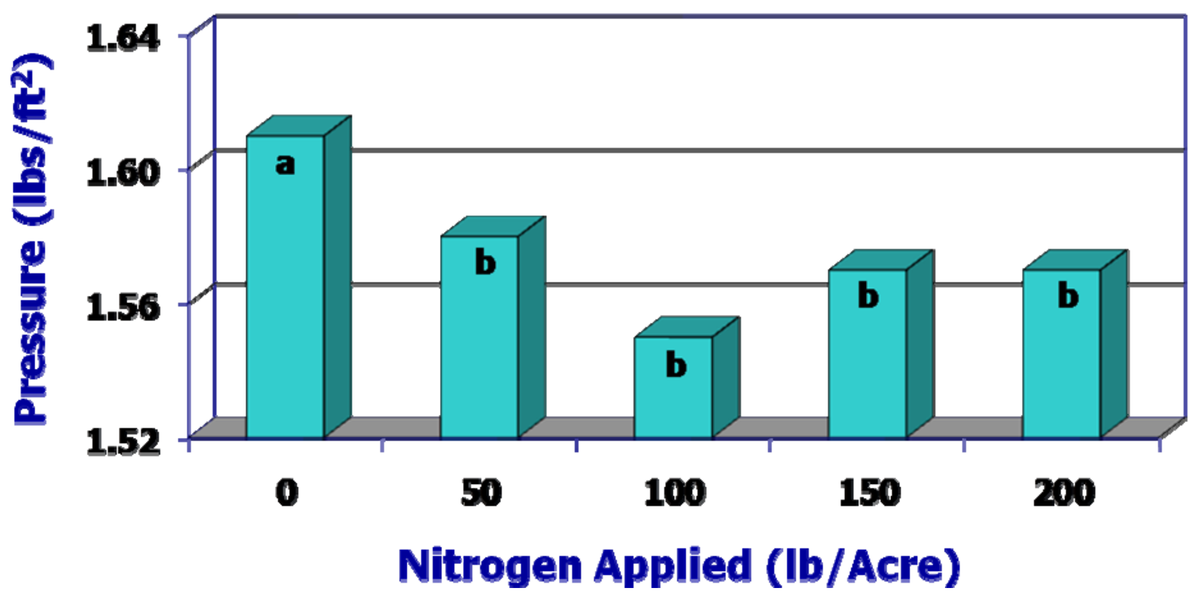

Figure 6. Amount of pressure required to puncture the carpel wall of cotton bolls aged to 350 heat units (>60 °F) as affected by variable nitrogen rates applied to the soil in replicated experimental plots, 2009.

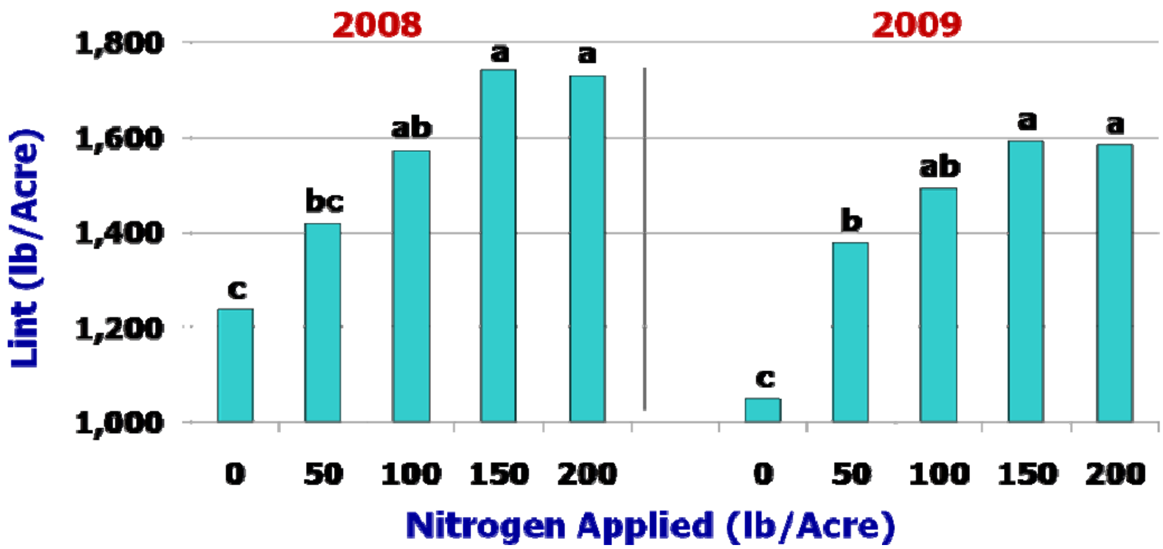

Figure 7. Effect of variable rates of soil applied nitrogen on cotton lint yield, 2008-2009.

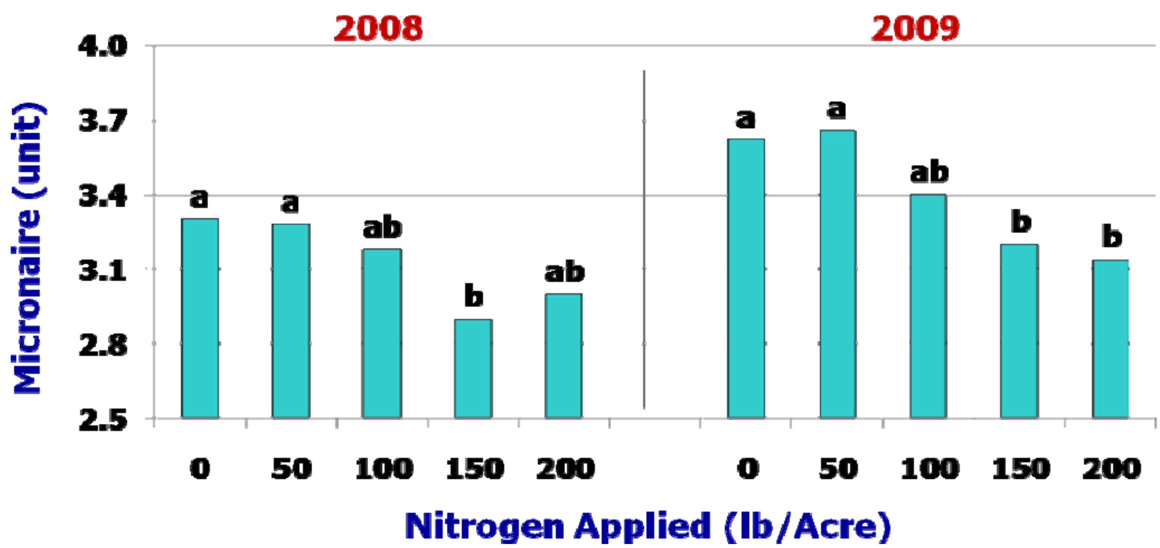

Figure 8. Effect of variable rates of nitrogen application on cotton lint micronaire values in replicated experimental plots, 2008-2009.